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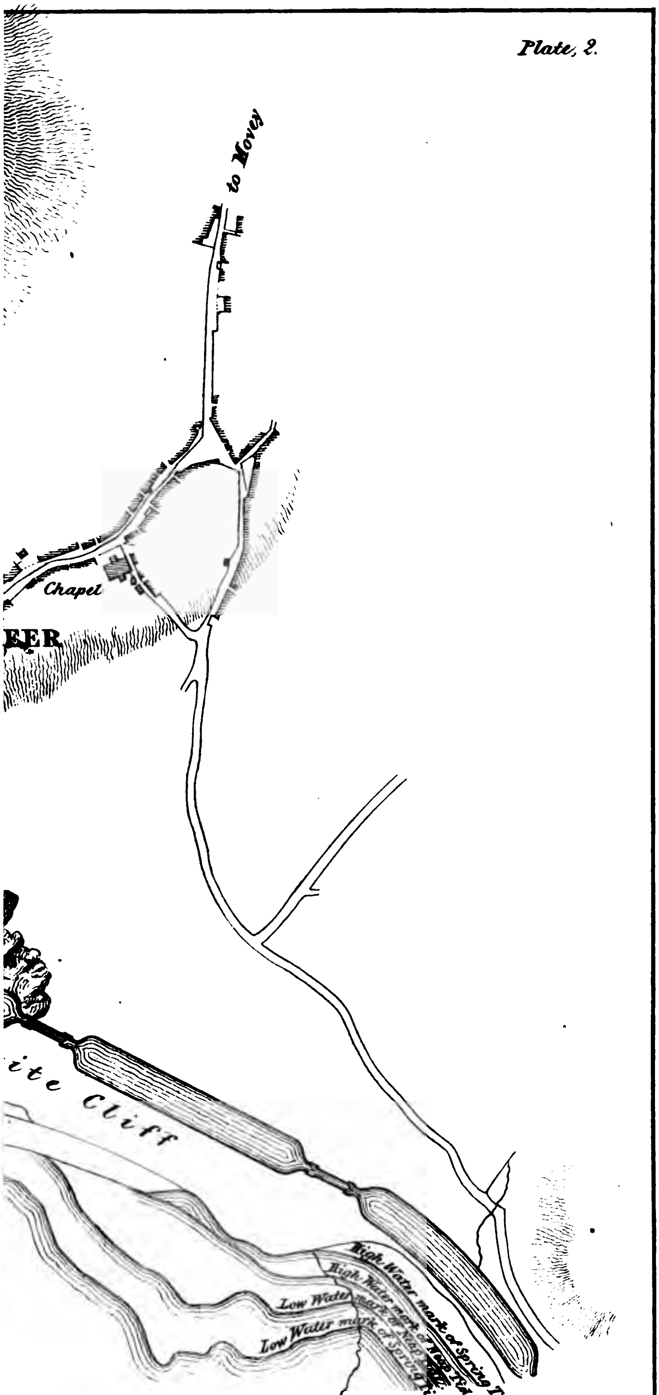
Plate, 2.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Low Water mark of Spring Tide.

J. R. Jobbins, Draftn & Litho. Warwick Ct Holborn.

AN ESSAY

ON THE

FORMATION OF HARBOURS OF REFUGE,

&c.

BODLEIAN · BIBLIOTHECA ·

AN ESSAY

ON THE FORMATION OF

HARBOURS OF REFUGE,

AND THE IMPROVEMENT OF THE

NAVIGATION OF RIVERS AND SEA PORTS,

BY THE ADOPTION OF

MOORED FLOATING CONSTRUCTIONS

AS

BREAKWATERS

OF THE FORCE OF THE SEA TIDES AND CURRENTS ON SEA COASTS,
AND AS REGULATING THE COURSE, DEPTH, AND FLOW OF
TIDAL AND UPLAND WATERS IN RIVERS.

BY

JOHN WHITE,
ARCHITECT;
AUTHOR OF "SOME ACCOUNT OF THE IMPROVEMENTS IN THE
WESTERN PART OF LONDON IN 1815;"
COMMISSIONER OF SEWERS, &C.

WITH SEVEN PLATES.

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PREFACE.

THE advantage to be derived from Harbours of Refuge wherever there is much resort or passage of ships and danger attending the navigation, is sufficiently apparent, and does not require any lengthened dissertation on the subject; and our humanity dictates that we should especially be attentive to the preservation of our mariners wherever a coast is particularly dangerous and frequented,—where, consequently, shipwrecks are hardly avoidable. The consideration of the best mode of constructing such harbours is that part of the subject which is proposed to be the first portion of the subsequent pages.

The regulation of the flow of waters in

rivers at a moderate expense is evidently a matter of great importance, and thus improving their navigation wherever the products or merchandise of their localities require interchange with those of other countries, or with those of the same country. The necessity of improvement in the Irish rivers has called for the laboured investigation which has taken place as to the condition and capabilities of the river Shannon (lately the object of much parliamentary discussion in our Houses of Parliament); wherefore it may neither be useless nor superfluous to endeavour to attract public attention to what is by the writer conceived to be a more ready and less expensive mode of effecting the improvement of the waterway of such rivers than has hitherto been adopted—evidently so, than can be accomplished by the erection of solid piers or by the construction of locks or weirs of masonry. The mode of producing this regulation is intended to be the second subject for reflection.

The third head proposed, is the adoption of floating frames as auxiliaries to natural headlands or to artificial stone jetties founded on the shores of the waters of rivers or the sea, and will have reference to the improvement of harbours, where the run of beach, shingle, or sand is detrimental by forming impediments to their entrances.

The fourth portion of this Essay will treat of the adoption of partly fixed and partly floating works to promote the deposit of beach, shingle, sand, silt, or any alluvial matter, so as to aid in forming, or rescuing from the ocean, lands in bays of the sea, or in the estuaries of rivers, which otherwise would continue covered with water. The writer has been particularly attracted to this part of the subject by the beneficial results which have attended his making a small open jetty for Lord William Bentinck, in 1810, at North Lynn, and the nationally important project of Sir John Rennie to embank the rivers of the Lincolnshire Wash, now before the public.

It will be the endeavour of the writer to discourse upon the above subjects with perspicuity; he will have to lament if the views which he entertains, and which he considers of great national as well as of general importance to mankind, shall, for want of ability on his part, be esteemed as insufficiently explained, or to be impracticable. He is aware that the means of effecting the objects which he submits to the public are not of a permanent nature; but at the same time he considers that their renovation will be less expensive than the interest of money and the repairs of solid constructions will amount to; and he believes that such measures as those he ventures to suggest can be brought into action, where others of a permanent nature never could,—more particularly in newly-explored or little-inhabited territories. He is also not ignorant that many of his ideas are not altogether novel; but he questions whether the public has ever had before it any dissertation on floating works which has led to practical results. His apprehension with regard to the advantage of this Essay is, that the subject may not possess sufficient interest to induce men of wealth and power to entertain the objects as matters of speculation; indeed he is almost persuaded that Government must take the lead, unless some united body of individuals, interested in the welfare of the sea service, shall boldly take up the matter as regards harbours of refuge,—or as regards internal navigation, a spirit of improvement shall arise in the mind of some powerful and wealthy persons, who shall perceive advantages fairly commensurate with the expenditure which necessarily attends undertakings of this nature. Nevertheless, he feels that his endeavours may not altogether be thrown away upon a discerning age, in which the profitable employment of the labours of the population forms an important feature of investigation, independently of pecuniary emolument, at this particular period.

The mind of the great Alexander was directed to the improvement of the entrances to the great rivers of Asia, as appears from the following extract from Arrian. The subject presented itself to him as a matter of attention in the midst of his conquests. The navigation of the Indus, the Tigris, and Euphrates are now, from our Indian possessions, of fully as much importance to the value and durability of our empire in India, as they were to that ambitious warrior. His expeditions at the mouth of the Indus, and the works he directed there, are noticed in the 19th and 20th chapters of the 6th book. The 7th chapter of 7th book is particularly interesting, and is as follows :—

" Then he committed the best part of his foot forces to Hephæstion's care, to conduct them to the Persian Gulf; while he, going on board his fleet, which lay ready at Susa, with his targeteers and agema and some part of his auxiliary horse, sailed down the river Eulæus to the sea. And when he was now not far from the mouth thereof, leaving there those ships which were shattered and out of order, he with the best of them sailed down to the ocean, and then entered the mouth of the river Tigris, the rest of the fleet passing through a canal drawn from thence to the Tigris: for of the two rivers, Tigris and Euphrates, which inclose Assyria, and give it the name of Mesopotamia, the channel of the Tigris lying much lower receives the water of the latter by many branches; and several streams also falling into its own bosom, it becomes a great river before it glides into the Persian Gulf, insomuch that it is everywhere impassable by a ford; for it spreads not out in breadth so as to diminish its depth, the lands on both sides being much higher than the water, and it is not dispersed through other channels nor conveyed into other rivers, but takes them into itself. For the Euphrates glides along a much higher channel, and is in many places of equal height with the lands on each side, so that several streams are cut from it; some constant ones, which supply the inhabitants with water, others only occasional, when the neighbouring countries happen to be parched up with drought (for rains seldom fall in these parts); whence it happens that the Euphrates at its entrance into the ocean is but a small river and easily fordable. Alexander sailed first down the river Eulæus to the sea, and thence along the Persian Gulph, and up the Tigris to his camp, where Hephæstion with the forces under his command waited his arrival. Thence, steering his course to Opis, a city on that river, he commanded all the weirs and other impediments which he met with to be pulled up, and the channel to be cleared. These weirs were put down by the Persians, who were unskilled in maritime affairs, to render the navigation of that river so difficult as to hinder any enemy's fleet from invading them that way. However, Alexander looked upon them as the contrivance of cowards; and as they were little hindrance to him, knowing they would be of no use, he ordered them to be entirely cleared away and the river laid open*."

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* Rooke's Arrian, vol. ii.: London, 1814.

January 1, 1840.

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AN ESSAY,

&c. &c.

SECTION I.

ON THE FORMATION OF HARBOURS OF REFUGE.

Isolated harbours.

THE utility of isolated harbours at such a distance from the land as to admit of ships working between them and the coast, has been properly noticed in the excellent periodical work, The Civil Engineers' and Architects' Journal, for April, 1839, p. 121; and I consider that Mr. Tait and Mr. Hyde Clarke deserve the thanks of the community for the communications which they have submitted in it to the public. The following extracts from that work and Captain Boid's History of the Western Islands, will explain the peculiar nature and character of Porto-do-Ilheo: the harbour there mentioned as isolated is, by Mr. Hyde Clarke, described as situated at the island of St. Michael, one of the Azores, opposite to the town of Villa Franca, and not above six miles from that of Ponte Delgada.

Description of Porto-do-Ilheo, at St. Michael's, Azores.

" From the nature of the basin," he says, " it may " be readily referred to a volcanic formation, and " this is supported by its general configuration as " much as by its situation with deep soundings " around it. It has all the appearance of an extinct crater; consisting of a wall of rock, rising " in most places 30 to 50 feet high, with a hollow " centre, and an opening on one side." As nearly as Mr. Clarke recollects, " it is about a quarter or " half a mile across, and at low water, in the centre, from 8 to 10 feet water, with a sheeting of " mud covering the bottom. The mouth is to the " north-east, or towards Villa Franca."

Capt. Boid states that " the interval between the " Ilheo and the town forms an excellent anchorage, from 4 to 9 and 10 fathoms, with good holding-ground; and it is this locality which I conceive presents more advantageous means for the " establishment of a port and harbour for vessels " of every size and draught than any other part of " the Azores.

" At the extremities of the town are two forts, " the one to the west being called Fort da Forca, " that to the east Fort da Arca, between which the " distance is little more than three quarters of a " mile, the Ilheo lying in front at pretty nearly the " same distance to the south-west. Off Fort da " Arca is a reef of rocks, just covered at high water, " and running out 100 fathoms in the direction of " the Ilheo. Upon this, as an excellent foundation,

Floating breakwater suggested.

"I would recommend the erection of a strong "breakwater, to be carried out in the same line at "an equal distance beyond the end of the reef, "which will be in seven fathoms water, the opening between which and the island would become "the eastern entrance into the harbour, to be defended from the heavy violent sea which sets in "with the easterly winds, by floating breakwaters, "moored in either single or double lines across the "entrance so as to form an effectual barrier.

"*Note.*—The floating breakwaters have been "proved by numerous trials a most efficacious substitute when the depth of water is found too great "for the use of stone. They become a barrier "against the heaviest sea, and where there is a "double line are of such effect, that a vessel may "ride to leeward with equal safety and tranquillity "as in a most sheltered port."

Communication with Admiral Sartorius.

The writer entered into communication with Admiral Sartorius, who, during his command at these islands, was desirous of putting into execution at Terceira an arrangement of floating breakwaters, so as to obtain a harbour there. He however left these islands suddenly, with the Queen of Portugal and the expedition to that country. Subsequently he has personally conversed with the writer on the subject, and has been supplied with models and information with the view of forming a protection for ships at the mouth of the Tagus. He is at present at Lisbon.

The advantages of a volcanic crater for a harbour, such as that of do-Ilheo, are superior as they respect a founded work, but there are circumstances peculiarly favourable to a floating construction, which such a harbour can hardly possess. A crater has not altogether the benefits of access which an artificial harbour can have, the entrance of which can be made wherever the winds, tides, or currents render it most desirable: it never can be silted or filled by beach or other moveable substances; on the contrary, the frames will have a tendency to increase the depth under them by the escape of the tide or current: and if by accident or stress of weather the mouth cannot be easily made, the breakwater frames will to a certain extent give way, with little or no injury to the vessel which may strike upon them.

Advantages of isolated harbours.

Isolated harbours upon a floating principle have a great advantage over those on the main land, inasmuch as ships can always avail themselves of a favourable wind in a very short space of time; and when any moderate works on the main land, such as will admit of landing from smaller vessels, exist, there will be little difficulty in discharging their cargoes by lighters.

Proposed harbour at Redcar.

The late debate in Parliament on the project of establishing a harbour of refuge at Redcar, on the coast of Yorkshire, has afforded ample demonstration of the necessity of works of this nature, and although the measure was rejected on account of its aiming at the subjection of vessels to a passing toll (which is an imposition certainly extremely objectionable), yet the benefit was universally admitted of affording along the coasts of England some accessible places to ships in distress and shipwrecked seamen. In one of the experiments tried by the writer, he had ample demonstration of the use of a single frame. On the 18th of November, 1824, a frame of about forty feet by thirty, consisting of three tiers high of Quebec pine timber, and moored by an inch and a quarter chain cable, and thirty-two hundred-weight anchor, rode out an extraordinary gale at Dover. A fourteen-feet boat was anchored in the lee of it, and appeared from the shore quite at ease, until she was filled by the fine spray which the breaking of the waves upon the frame produced, and at length sank without injury; it was apparent that had she been decked, or could have been baled, she would have weathered the gale equally with the frame itself, which suffered no injury. This circumstance proves that refuge could always be afforded by even a moderate arrangement of frames for a pilot- or a life-boat; and when it is considered that one or the other would be able in ten minutes' time to put off on notice of distress, assuredly this small extent of assistance ought not to be withheld at those situations where there is frequent danger.

Trial of floating breakwater at Dover.

The question on the Redcar harbour led to a communication between the writer and the members for North Yorkshire and Sunderland, (Mr.

On Redcar harbour, &c.

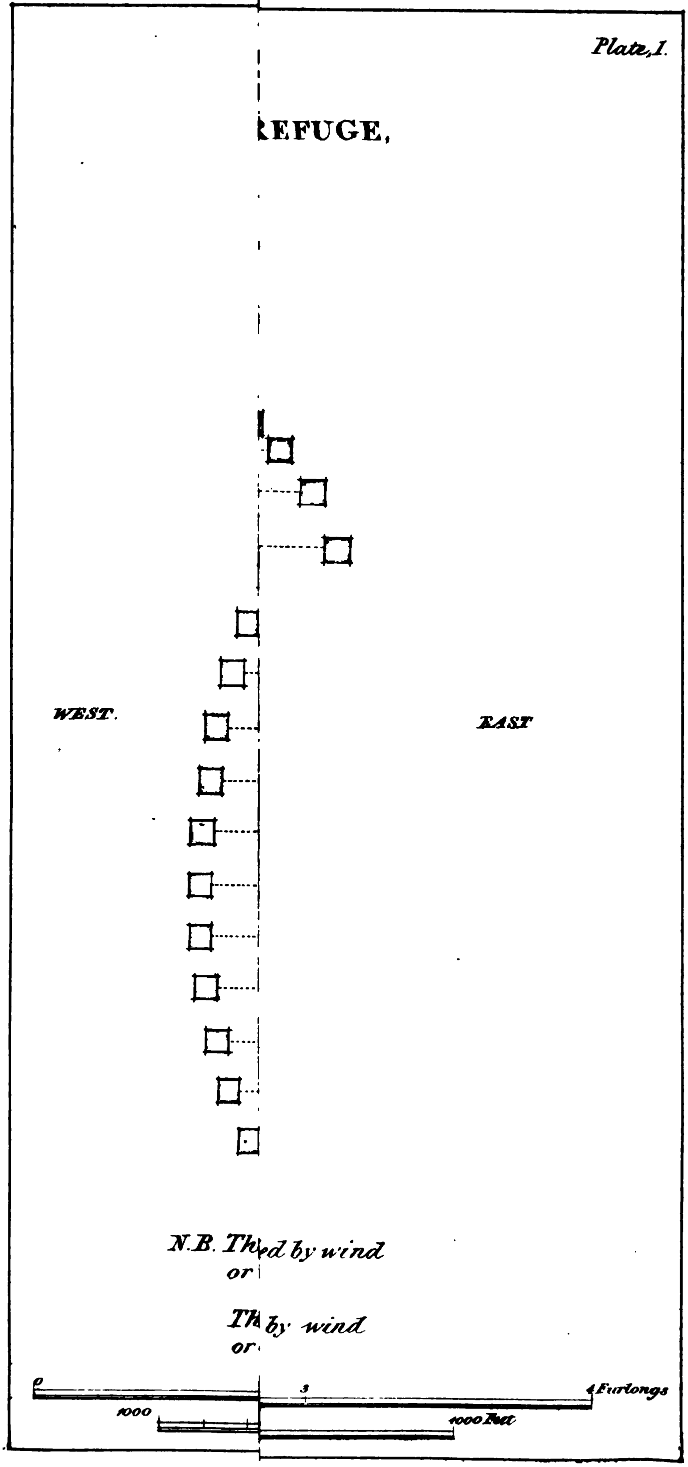
Caley and Mr. Andrew White,) who both took a laudable interest in endeavouring to induce Government to take up the subject. The former of these gentlemen expresses himself of opinion that Government will hardly do much of itself without being forced, but eventually he apprehended that the sense of the country would compel them to act. Mr. A. White placed the information communicated to him in the hands of the Shipowners' Society at Sunderland, and it is to be hoped that that active body will, against the ensuing session of Parliament, be prepared to submit some effective measure; that other members of both houses will be induced to support their views; and that, in addition to the calls of humanity and public benefit, the legislature will, as a body, be impressed with the necessity of improving every advantage which our own extensive coast and the shores of our colonies offer to maintain the marine ascendency which has so long been the glory of our country.

Plan for a floating harbour on a small scale.

The annexed plate (Pl. I.) may serve as a general idea of a floating Harbour of Refuge on a small scale, and for a situation where the effects of the sea are not particularly formidable. The positions of the black frames are intended to represent them on the flux, and the red frames show their situations on the reflux of the tide.

It will readily be perceived, that a ship might manœuvre so as to get within the interior of the curve of the breakwater frames, supposing the tide and wind were from the same quarter as the open-

Plate, 1.



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ing into it; but supposing the tide and wind were opposed, although the same general form would remain, a ship from windward must steer between the two impulses; she could, however, anchor in the lee without much difficulty, even if more than one vessel were aiming at the same object. The curvature admits of several of the frames acting together in certain directions of the wind and tide, and breaking the sea by their united efforts, which evidently is an important matter when the storm is very violent. The breakwaters here are supposed to cover a range of half a mile, as will appear from the scale.

The cost of this arrangement of frames for the coast of England, would probably be as follows:

	£.	*s.*	*d.*
24 frames of 11 logs (2 loads of timber to each log on an average) :—			
22 loads, at 4*l.* 15*s.* per load . . .	104	10	0
Ironwork in bolts, bars, &c.	50	0	0
Labour on frame	20	0	0
1 anchor and stock, 80*l.* Chain (60 fathom) 200*l.*	280	0	0
Laying down. Seamen	5	0	0
Contingencies, &c.	40	10	0
	£500	0	0

Twenty-four frames, &c. at 500*l.*, amount to 12,000*l.*, which would be the cost of the harbour.

In process of time there will be considerable adhesions of sea-weeds, barnacles, and other shell-fish: the sea-weeds will however but little affect the buoyancy of the frames; their attachment to the logs will assist the breaking of the waves and reduce the upper current of the tide. Should the barnacles and other shell-fish be in considerable quantities, their weight may be counteracted by additional logs on the top of the frames, or by casks: nothing, however, must be suffered to be loose; the timbers must be put together in the firmest manner, and the bolts and straps so contrived as to be at any time capable of being screwed or wedged up. The continual action of the waves tends to disunite the logs; but the experience of twelve months which the frame at Dover afforded, was that of demonstrating, that it was but little acted upon detrimentally to its construction.

Care must be taken in laying down the moorings, in order that the chains may not foul. The situation of the harbour should be selected so as to afford the best holding-ground, and where it is alike tenacious, because, if the moorings should become disturbed, there would be considerable expense in replacing them. The chains should be long enough to allow for a sudden strain; if they are too long they will drag the frame too much under the water. It would probably be most judicious to have the middle tier of each frame of the smallest-sized logs. It is not intended that the scantlings of timber should all be the same, as a perfect uniformity of dimension would increase the expense; but nothing less than thirteen inches square should be employed. It is not essential that the timber should be regularly hewn, as somewhat octagonally-shaped logs would not be disadvantageous, if at the places where they unite with the other logs there is sufficient strength. The timber should be as free from sap as possible, and without large knots, as such would endanger the breaking of the timbers in a storm, when struck with a heavy wave.

Other propositions as to floating breakwaters.

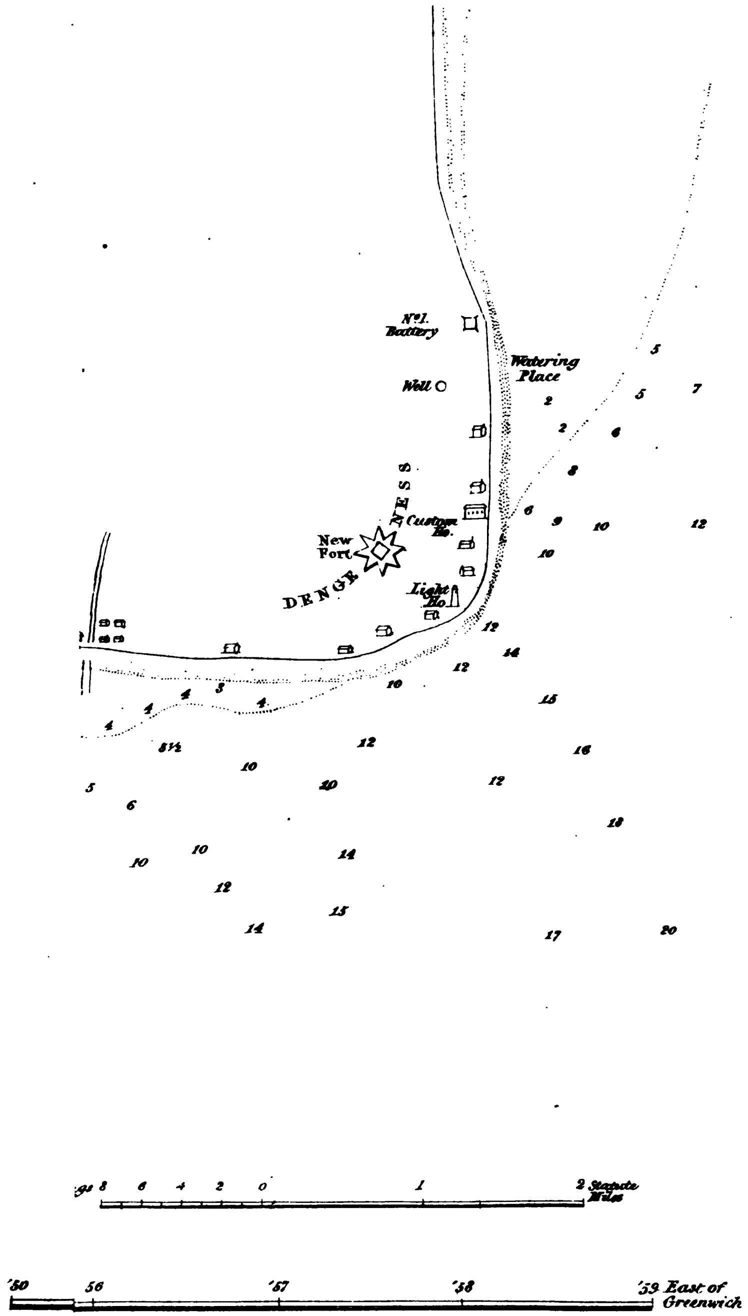
David Gordon, Esq., of Edinburgh, in January, 1822, took out a patent for improvements in steamboats and packets, and, as part of his patent, he embraces a plan for making a *chevaux de frise*, or an arrangement of spikes to be affixed to a floating frame, which he contemplates being anchored at a sufficient distance from the bow of a ship as a breakwater. Whether this contrivance can be employed upon a considerable scale may be questioned; as, however, it bears upon the subject, it may be properly noticed here, and also, that the late Mr. Bentham was of opinion, that a system of buoys could be so moored as to produce the effect of the breakwater at Plymouth. Captain Jekyll of the Navy thought that triangular frames would answer better than rectangular ones; but I am convinced that the larger the horizontal area or surface of the sea is, which can be sat upon or covered by the floating substance, the greater will be the protection afforded, and the more powerful will be the effect upon the progressive action of the billows. The gravity of the water soon produces a lull or calm by its natural tendency to be at rest: the only matters to be apprehended are the want of magnitude in the obstacles and their firm mooring.

Beer harbour. The late Mr. Telford fully felt the want of a harbour of refuge on the coast of the West of England, and his philosophic mind embraced a project for establishing such a work at Beer, on the coast of Devonshire. This asylum for ships is shown by Plate II., to which has been added a plan for a floating harbour, as this place is well adapted for an establishment of this nature.

On a harbour at Dengeness. There are many promontories or points of land on the coast of England, which, if they could be weathered, would become shelters under stress of weather, but which, becoming lee-shores, are the destruction of the ships which are driven upon them. As an example Dengeness may be instanced, where there are five and six fathoms water in a channel lying between a sand-bank to the south-westward of the headland, and which channel is buoyed at each end of the bank: the entrance to this channel is three miles wide, and is opposed to the most violent or south-west wind: the sand bank is nearly parallel to the coast, and acts as a defence, and Dengeness point is a guard to the north-east: thus every quarter is protected except the south-west, which is the dangerous point. This harbour, as

NGENESS, KENT.

Plate, 3.



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shown by the letter A, Plate III., consists of forty-eight frames, and would cost 24,000*l.*

Plate III. shows how a harbour may be formed at this place, and it is presumed that there is retentive ground at the mouth of the channel. Admitting that the floating frames are judiciously and securely placed, a harbour of refuge would be constituted where it would be of the most essential use. The buoys to a certain extent indicate that there is holding ground. In winds from the north-east this channel is frequently used instead of the Downs.

Objection made by the Admiralty.

In the year 1824, when the proposition of constructing floating breakwaters was under consideration by the Admiralty, it was stated that the whole coast of England would become accessible to smugglers wherever such works were laid down, and therefore they should not be encouraged. This apprehension must surely be untenable, because the situation of every floating breakwater would be as well known, and consequently be as easily approached and equally afford shelter to revenue cutters and to the smuggler; indeed, a contrary effect might be calculated upon than protection to illicit trade, viz. an increased knowledge of what was going forward on the coasts; for, as it would save expense, more government vessels might lie in readiness to get off shore at the least possible notice.

Julius Cæsar's floating piers.

The advantage of floating breakwaters was not unknown to the ancients. Julius Cæsar, in the first book of his Commentaries, De Bello Civili, section 25, describes his work at Brundusium, which is thus translated by Hooke, book x. chap. xi. p. 441 :—

"Cæsar, having lost all hopes of an accommo- " dation, and fearing that it was his (Pompey's) " intention to keep footing in Italy, resolved to " push the war with vigour, and to deprive him of " the advantages he might reap from the port of " Brundusium. The following works were con- " trived by him for this purpose.

" He carried on a mole on each side of the haven " where the entrance was narrowest and the water " shallow. But as this undertaking could not be " carried quite across the port, by reason of the " great depth of the sea, he prepared double floats " of timber, thirty feet square, which were secured " by four anchors to enable them to resist the fury " of the waves. These, which were to extend all " the way between the two moles, were covered " over with earth and fascines, that the soldiers " might pass and repass with ease, and have firm " footing to defend them. The front and sides " were armed with a parapet of hurdles, and every " fourth float had a tower of two stories, the better " to keep the enemies' ships at a distance, and " to guard the work from fire and the shock of " vessels*."

Pliny's account of a stone breakwater at Centum-

* Pliny, in his letter to Cornelianus, describes the situation of Trajan's haven at Centumcellæ (understood to be Civita Vecchia) thus: "This delightful villa is surrounded by the most verdant " meadows, and commands a fine view of the sea, which flows

Observations by the writer on floating breakwaters and their advantages.

It is not presumed by the writer, that he has, in the preceding Plates, laid down the best forms of floating breakwaters, as it evidently must be a matter of investigation to propose any decided plan for a particular situation: his knowledge is only a very general one of the places where he has supposed the principle of floating breakwaters can advantageously be adopted. The diagrams which he presents to the public are submitted with the view of explaining as popularly as possible his ideas; and in the drawing of Beer Haven he has endeavoured to show, that with forty-eight frames, laid down at the expense of 24,000*l.*, a harbour of refuge may be created, probably as beneficial, as an asylum harbour, as

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" into a spacious harbour in the form of an amphitheatre. The " left hand of this port is defended by exceeding strong works, " and they are now actually employed in carrying on the same on " the opposite side. An artificial island, which is rising in the " mouth of the haven, will break the force of the waves, and afford a safe channel to ships on each side. In the construction " of this wonderful instance of art, stones of a most enormous " size are transported hither in a large sort of pontoons, and being piled one upon the other, are fixed by their own weight, " and gradually accumulating in the manner of a natural mound. " It already lifts its rocky back above the ocean, while the waves " which beat upon it, being tossed to an immense height, foam " with a prodigious noise, and whiten all the sea around. To " these stones are added large blocks, which, when the whole " shall be completed, will give it the appearance of an island just " emerged from the ocean. This haven is to be called after the " name of its great founder (Trajan), and will prove of infinite " benefit, by affording a very secure retreat to ships on that extensive and dangerous coast."

cellæ, lib. i. 31. b. 4. *Melmoth's Translation.*

the more difficult and expensive work contemplated in 1824. It has been said that a single floating frame, although it may reduce to spray the wave which breaks upon it, yet that many waves will miss it; this is unquestionably true; but it is obvious, that if a floating breakwater of many frames be moored in a curve-line and properly opposed to the tide and the prevalent obnoxious winds, it will offer not one but very many of the frames, which in succession will receive the impulses of the billows, until at last it will subdue or tranquillize them as a multitude of reeds or weeds do the waves in an internal lake of water.

The mariner will soon discover where his ship will be most efficaciously protected, and where he can moor his vessel so as best to avail himself of a lull of a shift of wind. A preparation for landing might be made on some of the largest and least exposed of the frames, by rings, railing, and slips of wood on the logs: without some contrivance, the logs will be very slippery, and hardly admit of being landed upon; but a decked boat might always be moored so as to afford refuge on these emergencies.

The preceding observations have been confined to the formation of floating harbours of refuge near to the shore; but a perusal of the House of Commons' Report on Harbours of Refuge, of June 16, 1836, leads to an opinion that harbours of refuge might also with great advantage, and in some respects with superior advantage, be situated out at sea, where there is good anchorage. Unquestionably, where there are no land protections, those to be formed by floating constructions must be of greater magnitude and more extensive as to their superficies, as well as consisting of more ranges of frames. It appears in Mr. Cubit's (the engineer) examination, that 300,000*l.* would be the probable expenditure in making a harbour at Port William, for which he had given in plans; and when it evidently appears from this Report that 200, 300, and even 400 vessels are frequently driven by stress of weather upon the extended coast from the Thames to the mouth of the Tees, without any good place of refuge, such an expenditure does not appear a very exorbitant sum. Yet if a floating harbour, such as that suggested at Beer Head, can be constructed for the sum of 24,000*l.*, the doubling or trebling that amount, either by increasing the number or magnitude of the frames, and placing them (with good anchorage) in the open sea, at the expense of 100,000*l.* for each asylum so constructed, would allow of three breakwater harbours being situated on this length of coast; suppose one off Yarmouth Roads, one off the coast of Lincolnshire, and one off the coast of Yorkshire, costing only the same amount. Jealousies as to situation would probably be avoided by this arrangement, and the object fairly attained: their maintenance would not be more expensive than that of the stone works proposed by

Mr. Cubit, but probably a light might be requisite at each asylum. Mr. Walker remarks (p. 83.), that timber is a useful addition in the construction of a harbour; and it is to be observed, that pure sea-water does not encourage the auger-worm, so destructive to timber in mixed fresh and salt water.

The important and much-debated question as to levying passing tolls, would apply less to asylum-harbours in the open sea, and especially to one which might be made in the Downs, because the situation of the Downs perfectly defines what may be considered a passing ship in the strictest sense of the word, which as regards an open sea admits of much ambiguity.

As a Summary,

—a cursory review of the principle and peculiarities of the floating breakwater, will prove its very decided superiority over stone piers and fixed breakwaters.

In the case of the stone pier, the wave impinges on a fixed surface, and an increase of agitation follows; a new current, in short, is produced on either side of the projection. The floating breakwater, on the contrary, presents a *yielding* surface, and a succession of yielding surfaces; a part of the wave or current passes under it, and an equalization of the waters is thus the more quickly produced on the lee side. The *modus operandi* is this: The wave first breaks upon the outer broadside of the frames;

from the buoyancy of the frame, very little of the wave is dashed backward—part of it passes under the frame, and part of it flows over: in this broken state the wave strikes on a second bar, when it undergoes the same crippling process, and so on successively to a third or fourth, till the swell, more and more enfeebled, is at length completely subdued. The fact is, a very small quantity of the strongest billow will reach the leeward side of the frame.—This is the principle of the floating breakwater, and one which is proved to be as efficient in practice as it is satisfactory in theory.

Such is the nature of the materials and the workmanship, that the *expense* of such a machine, compared with that of erecting fixed structures in deep water, is at least twenty to one in its favour.

But it is not in the first expense only that the advantage of the floating breakwater consists: it has many accessory ones.

It requires no backwater to clear the harbourage it produces.

It is approachable equally in every state of the tide. If properly moored, it rises and falls with the varying heights of the tide.

It is always reparable with ease, and obviously at much less expense than stone work.

It is capable of *removal* at any time, and to any place. This quality presents an important advantage. If a decay of trade at any place makes these breakwaters at any time unnecessary, or a state of war renders the facilities for landing afforded by them imprudent, they are readily removed; and of course it is more advantageous to displace a power at once, and without loss, and apply it elsewhere, than to break down and disperse a mass of masonry, with great labour and expense, and without the possibility of indemnification.

It may be multiplied to any extent that the growth of trade at any place may require. It is calculated again for all places and all countries.

It is particularly desirable for fishing coasts, where the surge often prevents boats from putting off and landing, and thus impedes the regular supply of the market, and makes the life and subsistence of the fisherman very precarious.

It is equally applicable to bathing-places. Bathing is frequently interrupted by a rough sea, to the great detriment of invalids, and the disappointment of those who bathe for pleasure. The floating breakwater will at all times command smooth water, and protect the machines.

SECTION II.

ON THE IMPROVEMENT OF THE NAVIGATION OF RIVERS.

Description of streams at their sources.

THE greater portion of those streams which are of any importance for navigation, may be considered as those which are derived from sources considerably inland, which almost universally have very small beginnings: these origins, generally speaking, are situated where there is much declivity of country, and when consequently the flow of the water is impetuous and shallow. I shall forbear to treat of the improvement of a river of this description, before it attains such a bulk of water, and such a width between its banks, as conveniently to admit of the passage of a boat or barge capable of carrying five tons of lading.

It almost universally happens, that the course of a stream of this nature is tortuous, and is in its progress destructive of the banks both on the promontory sides and in the bays; the water flowing through the channel carrying along with it much of the soil washed from the sides and bottom onwards until it arrives at the mouth or estuary, where, meeting the sea, it, during slack water or tidal eddy, deposits the soil it has been charged with, which constitutes the sand banks or bars so injurious to navigation.

Direction of streams in rivers.

It is obvious that an arrangement of floating timbers*, secured ascant the stream so as to give the current a direction as much as possible in a straight line, will have the effect of saving the banks to a great extent, and that, according to the magnitude of the obstruction created by these timbers, the water will be penned back: to explain which, let the annexed plate (Plate IV.) represent such a river, A being the point where it is navigable for craft of five tons burthen.

It is proposed to show that the current of this portion of river first impinges upon its right bank, at the point B, whence it is repelled or driven forward, in the direction of the arrow C, into the bay or coved shore D, and thence again pursues a course in the line E onward, till it meets some impediment, or is again reverberated by the bank G in a similar way; always, according to the velocity of its current, carrying forward more or less of the soil, or depositing the heavier part of the alluvial matter at the places where there is eddy water, which are shown by the dotted parts of the stream, as F F F.

By deflecting or reflecting their currents.

Now supposing that one or more floating logs were judiciously secured in the river, at or near to the point B, athwart the stream, as shown by the red line nearly opposite to B, the current would be thrown more into the bed or middle of the river,

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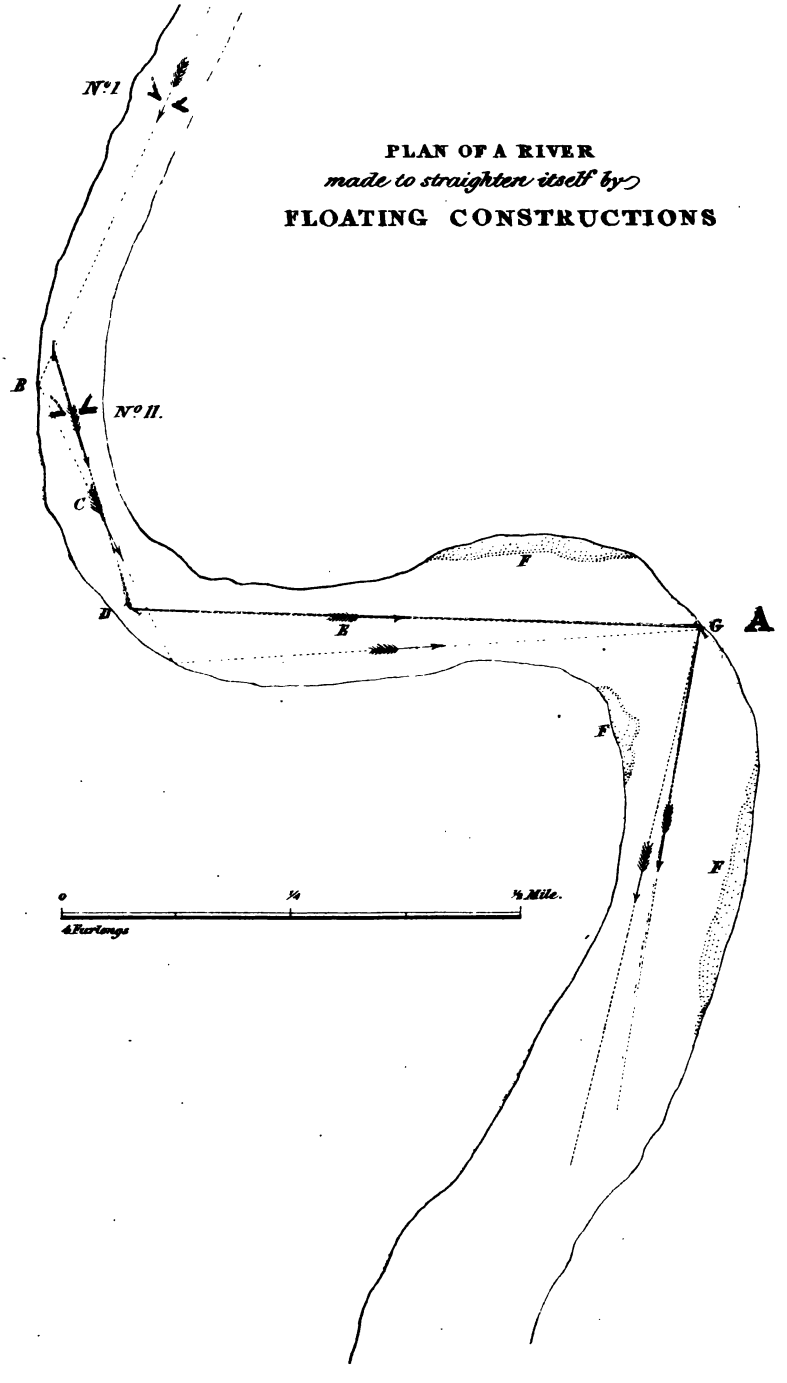
* Sir John Rennie very properly terms a jetty of fixed timbers, a barrier, in his able Report on the Lincolnshire Wash,—now before the public.

Plate 4.

PLAN OF A RIVER
made to straighten itself by
FLOATING CONSTRUCTIONS



J. R. Jobbins, Draftˢᵐ & Litho. Warwick Cᵗ. Holborn
Published by J. Weale, Architectl. Libʸ. 59, High Holborn, Janʸ. 1840.

as described by the red dotted line and red arrow, till it is opposed by the next floating logs, as shown by the line above the point D; whence again a new improved direction of the current may be given, indicated by the second red arrow and dotted line, to the floating logs at C; and thence still forward by a like process, till the course of the river shall have become better adapted for navigation from the bulk of the water being impelled into the middle of the channel.

It will thus appear that the currents of rivers, as to their courses, may be made to improve themselves, by the action of the water upon floating impediments applied to direct their serpentine currents into a desired line. These impediments are considered as capable of acting with greater advantage than any solid or foundation work can do, and at a very little comparative expense. The situations of these floating breakwaters can be changed according to circumstances, either when their intended effect has been produced, or when, from observation, their action can be improved by increasing or diminishing their magnitude, or by changing their direction: the general effect will however be, that as the angle of the incidence of the water in current is on the logs, so will be the angle of reflection from them; consequently, it may not be very difficult to determine their particular situation: their depths and lengths must however be proportioned to the power of the river. Probably logs thus arranged will be adequate to direct a stream such as is here considered as navigable for craft of five tons burthen.

By pending back their waters.

It is necessary, in addition, to show that a further beneficial effect may be obtained by floating substances put differently into operation. Let us consider that this portion of the river has at certain periods of the year redundancies and deficiencies of water, and that there are shallows or rapids at the places marked No. 1. and No. 11. on the preceding plan, which require improvement.

Let us suppose that connected logs are, instead of being placed ascant the stream, so situated as to keep back the water contained in its channel, and kept at the command of the conservators of the river by having chains at either end, one of which chains shall be secured to the bank, the other so fixed as to maintain the logs directly across the current. If this be done on both sides of the river, there will be a rush of water between the ends most distant from the banks, which will constantly act in deepening the passage in the middle and generally along the bottom, carrying away the soil until it finds eddy water, where it will deposit its weightier parts. Let the blue lines represent these logs; it will be obvious that the river will be deepened at the shallows as described.

Motion of alluvial matters in streams.

It may be said, that the evil of sending the soil of the river forward will produce all the inconveniencies of shallows in other places instead of those places from which it is removed, and that at the times of floods, especially when they come unexpectedly, the water being opposed by these breakwaters may do great damage to the adjoining lands. It must be admitted that these are consequences attendant upon the system, and are therefore to be guarded against by the attention of the persons employed to protect the stream. Protection can be readily given by drawing the middle ends of the logs to the shores, and securing them there at periods of floods, where they may remain until slack water shall require them to be replaced: this is a circumstance which cannot attend solid or founded works, such as weirs, nor the ordinary locks, although the opening their sluices and their gates partly effects the same object.

If a shallow or rapid should exist at the turn of a river where the navigation is required to be improved, the following arrangement of floating breakwaters is suggested as applicable to the purpose. One end of the united logs is proposed to pivot at or near the bank by a short chain and swivel, the other end to be acted upon by a longer chain and mooring, secured above at such a distance as to admit of its being lengthened according to circumstances. Opposite to this arrangement of logs it is proposed to place a set of logs in such a direction as to inflect the stream into the middle of the lower part of the river; thus vessels coming down the river would obey the current, and coming up they may avail themselves of the logs to warp where the force of the water is most severe.

It can hardly be objected that these impediments will prevent sailing, because they are proposed to be placed where shallows occur, which are themselves at most seasons of the year such obstructions as to require remedy.

Improvement of Irish rivers.

In the year 1835, the Board of Works at Dublin being impressed with the utility of improving the navigation of the Irish rivers, a correspondence took place between the writer and the Board, which was attended with the observation made by the Board, that they found the system of floating breakwaters extremely interesting, and that should the Commissioners find occasion to try them, the writer would be consulted formally and officially upon the matter. It appeared, however, that there were no funds then in existence applicable to the trial of any measure, and it has not been until very lately that Parliament has voted any money for the purpose of improving the rivers of Ireland; when this largess was confined to the improvement of the river Shannon.

The Shannon.

No river requires both solid and floating constructions more than the Shannon does; the only question which presents itself to the writer's mind is, how far the one or the other of these modes of acting upon the stream will be more generally beneficial, taking cost and time into calculation. The excellent detailed drafts, plans, and explanations of the condition of the river contained in the Parliamentary Report present materials for considering or attempting both modes; and, indeed, when it is observed that the advance has been somewhat reluctantly voted by both Houses of Parliament, it becomes more particularly necessary that economy and discretion should be used, and that whatever measure may be adopted, it should be the result of a full investigation of whatever has or may be proposed in time; also, whether it will not be more advantageous to spread improvements over the whole of the course of this river at places where they are immediately wanted, to the making large and expensive works at the entrance, or at any particular places.

River Thames at London.

In last year, 1838, I submitted some propositions to the Committee of the Thames Navigation, for preventing the extreme shoaling of the water of the river between Vauxhall and London Bridge, and the following is the substance of the correspondence and conferences which have taken place on the subject.

After alluding to what had passed on the subject of London Bridge between the Committee and Dr. Olinthus Gregory and Mr. Telford, as to the effect of its removal, and also to the observations made by Mr. Robert Erskine in his letter to Lord Mayor Beckford in 1770, I submitted a model, showing how, by floating caissons, constructed similarly to the long Reading or Kennet barges, the water might be kept up to a moderate depth in mid-channel.

I had a long conference with the Committee, and was requested to submit a plan for improving the portion of the river between Waterloo and Westminster bridges, which was admitted by the Committee to be very difficult to be navigated on account of the islands or shallows in the middle of the river: it was opposed to my observations, that whatever shoals might be removed or diminished by my proposed plan, the substances removed would accumulate somewhere lower down the stream.

In consequence of this request, I addressed to the Town Clerk the following letter, viz.

" Devonshire Place North, Marylebone,
" Jan. 7, 1839.

" Sir,

" In the absence of proper plans and sections of " the river Thames, exhibiting that portion of the " river which the Navigation Committee refer to in " their communication to me of the 26th ult., I " am thrown upon my recollection (only) as to the " present condition of the shoals in the water-way, " and the position of the lightermen's roads, as well " as to the situations of the discharging or resting-places for craft now in use in the said water-" way. I have, however, subjoined a sketch of my " said recollections, with a reference thereto, and a " few observations as to the improvement of the

Plate, 5.

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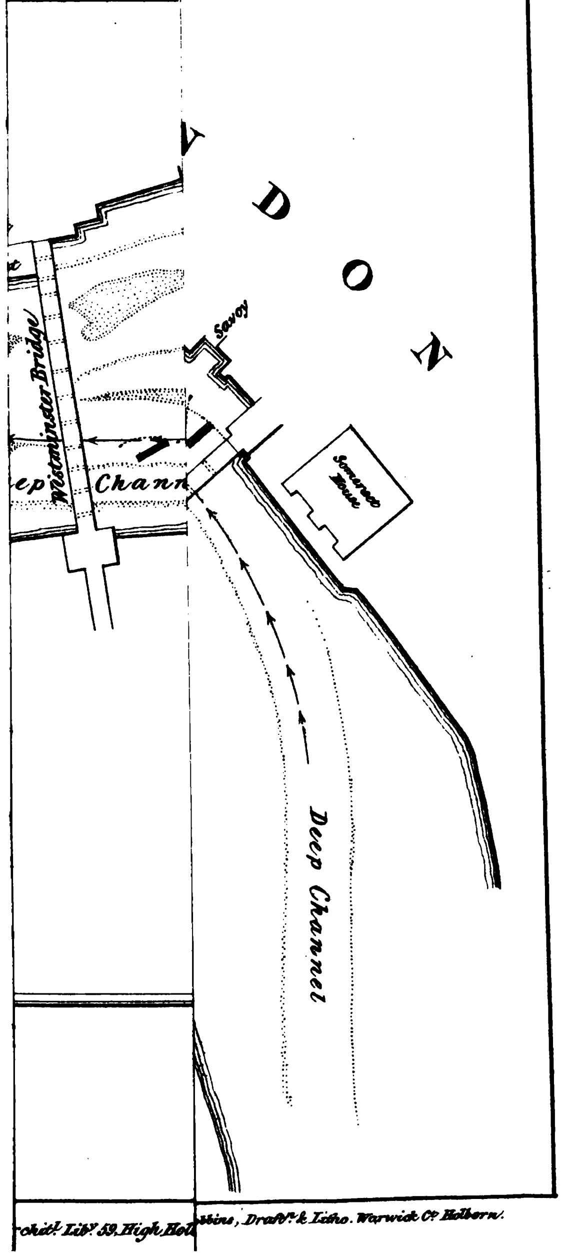

rchitl. Libr. 59, High Hol bbins, Draftr. & Litho. Warwick Ct. Holborn.

" channel, or rather, the conversion of the present " two channels into one, which the Committee re- " presented to me to be a great desideratum.

" First, I have to observe, that the downward " current of the river above Westminster Bridge im- " pinges so sharply on the shore of the Penitentiary " embankment that the stream becomes divided or " split by the craft at the lightermen's road below; " the stronger portion directing its course to the " Surrey arches of Westminster Bridge, the weaker " keeping the Westminster shore, running sharpest " on the embankment-wall and coffer-dam of the " House of Commons.

" The Surrey-side stream continues its course in " the deeper of the two channels which extend be- " tween the Waterloo and Westminster Bridges, " running hard upon the craft and the shore near " King's Arms Stairs; thence it crosses the bed " of the river, and, uniting with the Westminster " stream, one common current proceeds to the " Savoy and under the Middlesex arches of Wa- " terloo Bridge.

" Secondly. The upward stream or set of the " tide nearly reverses the above-described courses, " with, however, some considerable variations, pro- " ceeding from circumstances occurring below Wa- " terloo Bridge: these variations produce the irre- " gularity of the shoals, which are indicated by the " changeable depths of water in the middle ground " and on the shores.

" The use of the dredging engines has produced " some partial changes; and as the Committee in- " formed me that their operations were now regu- " lated and directed by their officers, instead of their " being, as formerly, suffered to work where their " owners pleased, I propose that they should act " in co-operation with the plan now about to be " submitted by me; viz.

" That the moorings of the lightermen's roads " should be so disposed above Westminster Bridge " as not to divide the stream.

" That two, three, or more floating caissons " should be placed a little below the second and " third arches of the Surrey side of Westminster " Bridge, and so moored, as to be capable, at the " direction of the City officers, of throwing the " current angularly against the island shoal, which " is shown in Plate V.; and that the lighter- " men's roads should be so arranged as to aid " this operation: also, that the dredging engines " should be directed to work in furtherance of the " object.

" That the craft on the Middlesex side from " Scotland Yard to the Adelphi, should be regu- " lated in their positions (if practicable) so as to " throw the downward current towards the middle " of the river and against the main island shoal: if " this cannot (having a due regard to property) be " done, one or more floating caissons may advan- " tageously be employed at a situation where they

" can conveniently act so as to keep up the return " tide and further the removal of the bank at the " same time.

" At Waterloo Wharf, or opposite the Savoy, " two caissons at least should be placed, so as to " be capable of almost obstructing the portion of " the stream which would run against them on return tides, which they would do if they were so " moored as to assume a position rectangular with " the shore, or somewhat in the line of the longitudinal position of the bridge, but at a little distance " from it.

" My aim is to employ floating constructions in " preference to embankments; first, on account of " their offering little impediment to the flowing " tide; secondly, on account of the great uncertainty of the action of embankments; thirdly, " because of their inconsiderable expense compared with founded piers; and fourthly, on account of their ready removal when their object " is accomplished, or if they were injudiciously " placed in the first instance, which is frequently " the case in founded works.

" It must be obvious, that the time which would " be required to effect so important a change in the " bed of the river as the reducing the two channels " now existing in it, as before mentioned, into one, " and to have this one channel midway, or nearly " so, between shore and shore, must be uncertain: " floods from the uplands, gales of wind from the

" westward, and excessive tides, would contribute to " its accomplishment, and the action of the dredging engines, properly directed, would contribute " according to the amount of that action. The effect " of the measure would, however, be generally and " immediately felt, in a greater or lesser degree; " and inasmuch as the ponding back the return " tides by the caissons proposed at Waterloo Bridge " would give an extra depth of water, the steamboats, which draw little, would be much assisted, " as even a few inches (and they easily could be " obtained) at the slack of the tide is almost essential to their navigation in this part of the river.

" Inasmuch as the carrying downward of the " silt, mud, and pebbles, independently of the " working of the steam-boats, depends upon the " quantity of the flow of water and its descent, I " do not perceive that these deposits will be much " greater than at present; but as every operation " tending to equalize the stream must correlatively " equalize its bottom, I judge that the deposit of " the substances moved from their present situations will take place in the present deepest part " of the river, excepting that the shortening of the " water-way, by effecting a mid channel, will, *quoad* " this shortening, naturally producing a sharper current, consequently carry further forward larger " and heavier pebbles than are at present moved " by its wandering course.

" With regard to the expense, let me assume

" four caissons and their appurtenances are in " the first place employed; these I estimate at " 500*l*.each, or	£2000	0	0
" Two additional, to act with them " as need may require	1000	0	0
	£3000	0	0

" I apprehend four men will be necessary; their " employment will be only requisite at change of " tide.

" Say four men, 25*s*. per week, 5*l*.; " 52 weeks, per ann.	£260	0	0
" Interest on 3000*l*., at 10*l*. per cent., " including wear and tear . . .	300	0	0
" Expense per annum . .	£560	0	0
" One of the men should have accommodation to live on board one " of the caissons, and the others " should act under his orders.			
" Say in addition to the above annual charge	40	0	0
" Total per annum . .	£600	0	0

" I have the honour to be, Sir,
" Your most humble servant,
" JOHN WHITE."

Embankment of the Thames at London.

The public are pretty well aware, that the Navigation Committee of London have been endeavouring to promote a scheme for embanking the river Thames, and that surveys have been and are making, in conjunction (it is said) with the Commissioners of the Woods and Forests, for the purpose.

Observations thereon.

However desirable an embankment of this nature might have been when it was first proposed, at the period of the rebuilding of London after the Great Fire, the present condition of the property abutting on the river is such, as to offer, on account of the expense, great obstacles to its accomplishment: but the particular object of this essay is to consider the advantage derivable to the navigation of the river if it were effected by floating constructions; from which object, however, are not excluded the facilities to be afforded, by which goods, and particularly coals, stone, and timber, may be landed on the shores by proper quays.

It is sufficiently evident, that whatever diminishes the width of the water-way on the flow of the tide is disadvantageous to the navigation both upwards and downwards, though not in so great a degree as has generally been supposed. It has clearly appeared that the removal of London Bridge has altered but little the high-water mark on either side of the river above its former site, although it has reduced the stream materially at low water: the inconvenience of its absence has been felt in the want of a pen or weir to keep back the downward stream, and thus having reduced the depth of water above its site. It is to remedy this evil that the conferences with the Navigation Committee took place; and it therefore becomes a matter of serious consideration, whether the sacrifice of wharf property. is necessary. The mud in this part of the river is daily decreasing by the action of the steam-boats, and will in all probability nearly vanish or be suspended in the current, which becomes proportionably more commixed with it.

Severn, Trent, &c.

The Severn and the Trent are rivers equally with or more improveable than, the Thames: they are both rapid rivers, the former more particularly subject to floods and shallow waters. The measures which have recently been proposed to regulate and render more navigable the former of these two streams, have been rendered abortive for the present by two parties looking at the peculiar interests of their own localities, and both projecting exceedingly expensive works; whereas, if both had aimed at one general improvement, the tonnage to pass upon a river running through countries abounding in mineral productions, the seat of our heaviest manufactured articles, and conveying into the heart of Worcestershire, Staffordshire, and Shropshire, foreign produce, must be sufficient to remunerate those persons who might embark in one common object of judicious improvement.

The same observation applies to the river Trent, and in a lesser degree to many other rivers in England; but I am inclined to believe that the Trent navigation has, for a river, the best-maintained internal navigation and the readiest canal communications. The Thames has of late years

The Thames.

been considerably assisted by the lockage of the lower part; and the rates of tonnage have been regulated, so that the excessively large barges, which sometimes were of 110 tons, are now seldom employed, but are supplanted by smaller ones of about 60 tons, which conveniently can be navigated when the former could not, even under the system of flashes, which is still used, where probably floating breakwaters would better answer the purpose. Within the influence of the tide no works of consequence, I believe, have been attempted, excepting the rebuilding of London Bridge, with a greatly increased water-way, since the time of the Romans, who are said to have embanked the river: and although the celebrated Mr. Brindley and others have suggested very important works, the Thames or City of London Navigation Committee have effected little to render one of the most certain streams in the world of the greatest public benefit; notwithstanding that the charge for tonnage is so high, and the other charges for freight so great, that a ton or load of timber costs as much to be brought from Maidenhead, as it does when imported from the Christiania Fiord in Norway.

Inference. These latter observations are directed more particularly to the consideration, whether the adoption of a cheap mode of regulating the water in rivers is more desirable than a system of lockage or solid weirs:—experiments upon an adequate scale would most correctly determine the question. These experiments cannot be made by an individual, or even by a body having no interest in, or power over, a navigation. If, however, the subject shall be brought sufficiently into notice, good may thence be derived, and possibly some of the money expended in the absurd opposition to bills in the Houses of Parliament might be saved and employed in the works themselves, instead of the maintenance of agents and lawyers in that worst of ordeals—a committee-room in either House; or perhaps in the establishment of a Board of men of theoretical and practical science, whose combined efforts might produce, without any prejudice, a beneficial judgment upon such matters as require public protection or assistance, and whose recommendation would justify advances of public money to forward the enterprises which to them shall have appeared likely to be attended with adequate public advantages*.

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* See the observation in page 46, on Longsound river in Norway.

SECTION III.

ON THE APPLICATION OF FLOATING FRAMES AS AUXILIARIES TO NATURAL HEAD-LANDS OR TO ARTIFICIAL JETTIES IN THE SEA OR RIVERS; AND ON ARRESTING THE RUN OF BEACH, SHINGLE, OR SAND BEFORE IT ARRIVES AT THE ENTRANCE OF NATURAL OR ARTIFICIAL HARBOURS.

Floating frames on lee shores.

In the first section, it was under consideration to afford protection to ships when in danger of running upon a lee-shore, or in stress of weather, by availing themselves of a harbour of refuge at a distance from the land. In this, it is proposed to exhibit the advantage of placing a series of floating frames at the point of any headland or promontory, where there is any good anchorage ground for ships, or a sufficient depth of water to suffer them to be moored without being affected by the ground-swell.

Calais Harbour.

The Harbour of Calais, the greater part of which is upon piles admitting the sea to pass between them, has therefore many advantages over that of Dover. Mr. Walker, in his examination on Harbours of Refuge (No. 1301, p. 83), says, that although just now (May 1836) we are building stone piers, (namely, at Dover,) timber is used, by way of breakwaters, to prevent the sea coming over the piers. I have not recently been at Dover, but I have been informed by a gentleman of science, that the mouth of the basin entrance is even now so continually choked, that the gates are under the necessity of being frequently relieved by dredging out the ballast which accumulates and prevents their being opened till this is done. I apprehend, that if Mr. Walker were to have placed a range of floating breakwaters of equal if not superior magnitude to those which in 1824 I proposed to moor south-westward of the entrance of the harbour opposite the point of Shakspeare Cliff, he would have been able to stop the roll of a great part of the beach. It was perhaps unfortunate, that Mr. Moon, who then had the control of the works, prevented the experiment which might have been attended with this important result.

Dover Harbour.

Mr. Moon's objection to placing any floating bodies westward of the harbour's mouth was, that vessels would run foul of them; he compelled the writer to place his frames to the eastward of the entrance, or opposite to the bathing-houses; so that the effect of the frames as to arresting the roll of the shingle was hardly to be expected to be ascertainable, as on the shore there is already an immense accumulation and the tide in eddy.

Mr. Moon's objection.

An examination of the ancient plans of Dover will lead to the opinion, that about the year 1500, the port of Dover, which previously to that time was in the valley between the western and eastern heights,

See Lyon's History, 1813-14.

was changed and formed out of the lagoon created by the deposit of the ballast or pebbles rolled from the south-westward, with its principal mouth or entrance in its present direction, and that, neglecting the principle of using the upland water and its current in a direct line to the ocean, mills and other impediments were suffered to exist upon it and impede its direct course; and the noble plan of Thomas Diggs, which had the entrance of the harbour immediately opposite to the river, was thrown aside, being considered as too expensive to be adopted*. The Channel Chart gives 7-fathom and 4-fathom water at this proposed entrance; and, admitting that there is little sand or silt carried forward by the sea in this place, there is no reason to suppose that the harbour would ever have filled up. The present depth of the sea where the mouth was proposed, demonstrates that for 240 years there must have been sufficient water even for men of war; and as Mr. Diggs had proposed two large stone jetties or groins, besides one smaller one in the direction of Chesman's-head or jetty, (since con-

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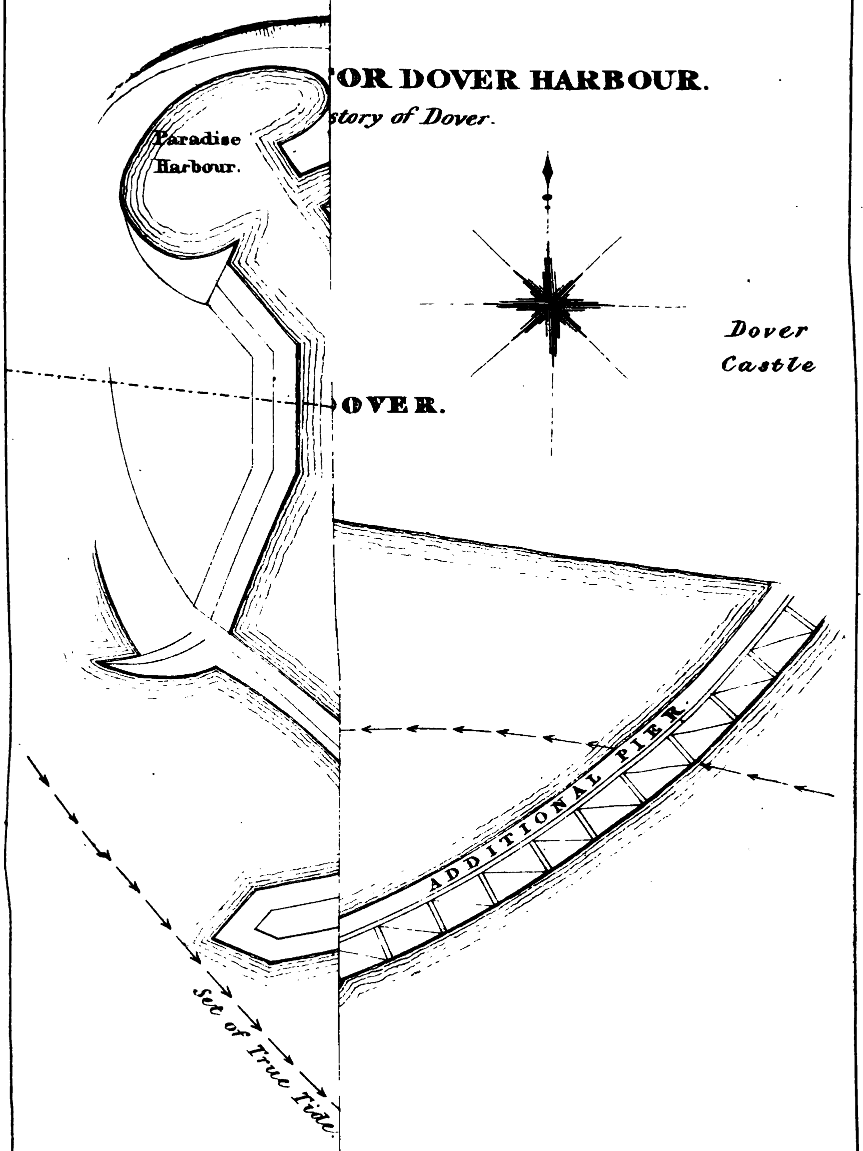
* See Plate V. which is copied from Lyon's History of the Town and Port of Dover (page 160, vol. i.) published 1813–14. In this page it is observed, that "there was a third scheme, to cut a passage through the town between the postern and St. Helen's Gate, and to have a harbour in the Meadows, near Stenebrook; and as this was the most absurd of the three, it was lately proposed for the consideration of the Warden; but it is hoped that death hath laid such a visionary scheme asleep." This would have been no visionary scheme, if the entrance of the harbour had been in its proper place, but quite the contrary.

Plate 6.



rt South of the dotted Line
he Proposed Improvement.

J. R. Jobbins Litho Warwick Ct Holborn.

structed,) it is more than probable that the beach would not have advanced so as to have diminished the depth of the sea to the above-mentioned 7- and 4-fathom; or supposing the sea to be now what it formerly was in depth at this place, its remaining so for so long a period is in itself evidence that this ought to have been the situation for the entrance of the port. The same chart indicates only 2-fathom water off where the present entrance is, and 10-fathom in the line where there is 12-fathom opposite the 7-fathom first mentioned.

Pent at Dover.

Whoever could have suggested the pent or reservoir at this place, instead of a direct opening into the sea, in my judgement totally mistook the principle of clearing a harbour or its mouth. In the first place, a pent constructed upon a foundation of shingle must be subject to an escape of water by its percolating through the shingle; secondly, the greater distance water has to flow on a level, so much the less will its power be to remove obstacles: this, indeed, was discovered previous to the operations of Mr. Moon, who in 1824 was making a water-tight chamber near the entrance of the harbour, and a culvert to convey the refluent tide directly against the shingle then accumulating at the entrance. This was a work of great expense, and I am informed that much more money has since been laid out.—Both these expenditures have profited little to the advancement of the object; and it appears to me that my own effort, if again tried, even on a more extensive scale, would only be partially beneficial, although it would afford a means of ships lying to the westward of the harbour till they could avail themselves of the top water of the tide to enter it*.

Floating frames at landing-places.

The use of floating breakwaters as auxiliaries to headlands or artificial jetties, as they would admit of vessels lying under their lee until they could enter a harbour, equally applies to coasts where there are landing-places, or where there is a necessity for discharging cargoes on the beach. Brighton has suffered much inconvenience for want of a protecting breakwater: its exposed coast and shallow water are disadvantages which operate against its trade, and, indeed, almost preclude the enjoyment to visiters of the pleasure of sailing upon the sea; the ground-swell is adverse to any breakwater of floating frames being moored near to the shore, but I am informed that there is sufficiently deep water at about a mile off or southward of the town. If floating breakwaters were there moored smaller vessels which could take to the beach might be employed to discharge freights of timber or coals from ships lying off the shore; and the landing at the chain-pier would in all probability be more frequented, since sea-sickness would abate with the stillness of the water, which might to a great extent be attained in the lee of the floating frames.

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* Since the above observations on Dover Harbour were written, I have read Lieut. B. Worthington's proposed plan for Dover Harbour. The fixed breakwater which he proposes may have a good effect; it will, however, be only a partial improvement,—the extension of the jetty, open or otherwise, will not prevent eddy-water depositing its heavy particles of shingle at the entrance of the harbour.

The flow of the tide upon a coast would certainly be divested of much of its inconveniences by floating breakwaters; this I personally experienced by placing myself in a Dover boat in the lee of one of those I caused to be moored in the bay of Dover. Although the tide set hard, and the wind blew a moderate gale from the south-west, I was in an eddy of the tide so completely, that the boatmen did not use their oars to maintain their situation, and I was able to write very distinctly in a book I brought with me for the purpose. I was informed, when one frame was moored off Deal, that a pilot-boat, which, from the strength of the tide, could not, for want of hands, set her sail, was able to do so by getting within the eddy of the frame, and thence bore away to the ship she was desirous of reaching.

As landing-places, floating frames are almost useless: possibly, however, preparations might be affixed to them, and in events of shipwreck, the lives of mariners might be saved by their having chains attached to them, which would admit of boats holding to for a period until the storm should blow over, or the seamen recruit their strength. Floating constructions ought always to be sufficiently moored to admit of greater strain than they of themselves would require, in order that such occasional adherences should not disturb their positions. It is more than probable that life-boats and fishing-boats would hang on, but this would not be for any lengthened period, as the tide would compel them to shift with it*.

Comparison of stone piers and piled piers with floating frames.

Compared with stone piers, it is evident that the superior advantages of floating constructions must depend upon the depth of water where they are used; and compared with timbered piers, such as that of Calais jetty, the same remark applies, generally speaking. Piles, to hold, should have one-third of the length driven into the soil: sticks of 75 feet (an excessive length for Dantzic timber) would be only 50 feet above the bottom, and this would be the extreme: probably 30 feet would be a full average required for a timber jetty. In this case the sticks would average the same length as the logs proposed to be floating; the quantity required would treble at least that which would be necessary afloat, and the expense of driving is great: but to oppose these expenses, there must be set the cost of the cables and anchors, the most heavy charges on floating breakwaters. I am therefore inclined to believe, that it is only where the sea is upwards of 30 feet deep at the top of the tide, that the two systems of founded and floating constructions come fairly into competition.

Floating frames or caissons in rivers.

With regard to the estuaries or mouths of rivers, where the tide or influx requires to be broken in order to protect landing-places, let us consider how the great tidal billow of the Severn might be broken or warded off to some extent at least.

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* The fullest consideration should be given to this point for the sake of humanity.

Let us suppose that a caisson suited to the purpose were strongly secured, yet to rise and fall with the tide, and to be situated at half a right angle or 45 degrees with the shore; it would almost stem the current running against it, partly by deflecting the bore and partly by opposing it, the water all the time rising under it or flowing into the angular recess between the shore and the frame, making a tidal eddy. In this eddy I apprehend boats or other vessels would be secure, and instead of their being drawn ashore, as now practised, they would be ready, immediately the tidal billow or bore has passed onward, to obey the action of the mariners. The danger to be apprehended is, the destruction of the frame on taking the ground, or from storms driving it against the bank. This breakwater must be constructed to meet these circumstances, and its situation chosen where it may best be protected against storms, and where its moorings may be most effectual. I apprehend a decked vessel would be best for this purpose, with a flat bottom and a head sloped off punt-like, according to the declination of the shore. Some difficulty would arise in regulating the length of chain: this I conceive would be overcome by a capstan on the bank of the river.

The bore of the Severn.

Lundy Island, in the Bristol Channel, is hardly approachable, except at particular times of the tide. It was proposed to place a floating breakwater there.

Lundy Island, &c.

I am not aware why the project was not persevered in, as it would have been very useful both to the owner of the property and to the ships navigating this frequented estuary of the Severn. I was informed that without an Act of Parliament enabling toll to be taken, there was not sufficient temptation to engage in the expense. The same objection to its adoption was made by the late Mr. Hollond as to Chessell Beach, and by the owner of considerable property at the mouth of the Humber, on the Yorkshire side, at both of which places a secure landing-place, or a position for ships to lie in order that they might discharge their freights, was considered extremely desirable.

Particular nature of frames to depend on circumstances.

It will appear from the preceding observations, that it is impossible to submit any particular form of floating construction for rivers; in the sea, frames such as those described in Plate No. 6. experience has shown to answer the purpose, and their strength of moorings has been ascertained; but the regulation of water in rivers must depend on local circumstances, as to the form and magnitude of the construction which best may be adapted to the purpose, and not a little upon the timber which can most easily be procured, of adequate magnitude and buoyancy. It may be necessary, if the timber is not buoyant, to attach casks or light caissons; but these should if possible be avoided, because there ought to be nothing loose, and every frame should be prepared so as to be able with facility to be tightened

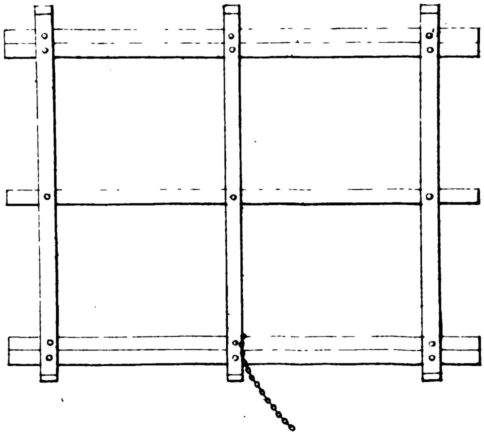
Plate, 7.

DESIGN

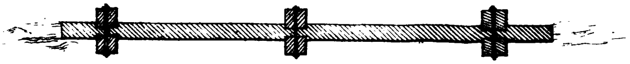
For a Floating Breakwater Frame.

PLAN

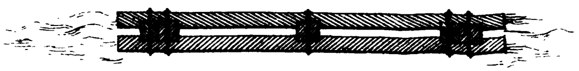
Open Frame.



Longitudinal Section.



Transverse Section.



J. R. Jobbins, Draftⁿ & Litho. Warwick Cᵗ Holborn.

Published by J. Weale, Architectˡ Libʸ. 59, High Holborn, Janʸ 1840.

up by screws at the ends of the bolts and wedges at the iron bands.

Severn improvements.

It is remarked in a late publication, that it is a singular exception in the progress of improvements which distinguish the present age, that notwithstanding the obstructions in the river Severn have been just matter of complaint during the last century, not a single plan has been executed to remedy or remove them, except the formation of some ill-constructed and much-neglected towing-paths; the channel of the river, where impediments principally arise, having been suffered to remain in its present dangerous and, in many periods of the year, almost useless state. While the Thames, the Mersey, the Clyde, the Shannon, the Ouse, the Air, the Calder, the Weaver, the Trent, and numerous other noble and extensively navigable rivers, have been improved either by the patriotic exertions of private individuals or at the public expense, the river Severn, notwithstanding its contiguity to some of the most thickly studded and thriving manufacturing towns in the kingdom, has been totally neglected.

Further, it is suggested, that the prominent improvements are to be effected by deepening and dredging the channel of the river, and by the erection of locks and weirs: thus, the existing impediments will be so far removed, that vessels drawing twelve feet water will be enabled to convey produce of every description thirty miles nearer to the principal districts of consumption, without incurring the present expense and risk of trans-shipment, damage to goods, and the immense expense of pilferage to which they are now subjected.

An examination of the Map of the Navigable Rivers and Canals of England, will demonstrate that the Severn is in fact a trunk to very many of the most important lines of water transit, and the above writer's conclusion will not be disputed as to its importance; but until some efficacious and cheaper mode can be employed than the erecting locks and weirs in the usual manner, it is debateable whether any adequate payment can be made in the shape of profit to those persons who may embark their capital in the execution of such works. Surely the simpler, the cheaper, and the readier mode of floating constructions should be tried, and their advantages or deficiencies put into comparison with the solid works suggested; and the deepening and dredging should be used only as portions of the scheme of rendering the channel of the river more regular, particularly in those parts of it where the bottom is so hard as not to be acted upon by any increase of rapidity in the current of the stream, which may be produced by the floating constructions which have been suggested.

Navigation of Long-sound river in Norway.

There is a singular instance of a navigation of a rapid at Brewig in Norway, which ships of 500 tons pass continually. A narrow passage between exceedingly high rocks divides the upland portion of the river of Longsound from the lower; both portions have very deep water; the impediment presented by this narrow passage becoming a natural lock and ponding up the water of the higher portion, which, up to another impediment near Scheen, has every accommodation for large vessels. The wind at midday commonly blows upward from the sea, when the crews of ships take advantage of it and pass into the upper level, by labour at the capstan, with boats, towing, and by warps or hawsers attached to rings fixed in the rocks. The passage is short, but the rapidity of the stream acting against an ascending ship is difficult to be overcome. Similar aids would unquestionably be requisite where floating constructions would limit the width of the stream considerably, and thus increase the strength of the current. Provision should be made for stemming this increased adverse current: where dispatch is requisite, a capstan with horses may be placed to give the requisite aid. I witnessed in 1817 the passage of the Porsgrund by the rapid of Brewig: the ship was in ballast, but was of 560 tons.

This circumstance is alluded to as an evidence that a river may be made navigable by ponding up the stream; and it is to be presumed that when artificial constructions admit of the water passing under them by their rising in time of flood, that they, from being more governable than solid and fixed impediments, will have every advantage over them, being so much less expensive.

SECTION IV.

ON THE ACQUISITION OF LAND IN BAYS OR ESTUARIES BY THE USE OF FLOATING CONSTRUCTIONS, BY RETAINING THE DEPOSIT OF THE SEA OR RIVERS.

Dugdale's History. Embankments.

THE Romans appear to have made very many embankments throughout this island, and to have acquired much valuable and productive land: from their works it is to be inferred that their embankments were not of very great substance, but rather lines of mounds one within the other. The statutes of Sewers and the laws of Romney Marsh show that the kings of England have, from a very early period, felt the importance of embankments; and the valuable work of Dugdale exhibits the great extent of land which had become profitable in various parts of the country. It is remarked by Mr Chapman the engineer, in his Facts and Remarks relative to the Witham and Welland, that the Romans embanked the country too early, and that had the tides and land-waters been suffered to spread themselves over the surface a few centuries longer, the lower parts of the then marshes would have been elevated by the continual subsidence of silt; there would have been no fens, and the drain-

Mr. Chapman's remarks.

age of the whole level would have been perfect and natural.

Mr. Chapman's Remarks objected to.

It is indisputable that rivers running through clay countries will continually bring down with their currents mud and silt; and in centuries the deposit in eddy waters and marsh lands will accumulate, and eventually may so elevate the flats, as that the whole level will have a perfect and natural drainage; and in addition to this deposit, the attrition of the pebbles, chalk, and other substances on the shores of the ocean, will, in the course of time, produce a vast quantity of sand or sea deposit. But it must not be admitted that generations of men are to lose the advantages which artificial works may effect, by waiting for the slow operation of time; and we must not admit that it was, as Mr. Chapman says, a fundamental error in the Romans, in executing the works which they did. On the contrary, I am persuaded that the works of the Romans consolidated the soil; and there is reason to think that to the double lines of embankment so frequently to be seen, in most instances is to be attributed the consolidation and effect of the first mounds, and that the interval between the two embankments, and also the space which the first mounds inclosed, were both increased in level by the introduction of the land-water at seasons when there was considerable sediment in it; and that when a drier season or period of the year was favourable, the superfluous water was discharged by properly-constructed sluices.

Proposition to embank the estuary of the Welland, Witham, and Ouse.

The public are in possession of much information of what has and what may be done in various parts of England by embankments; and the splendid proposition to acquire the soil in the estuary of the Witham, Welland, and Ouse deserves every encouragement. The present efforts of the writer are partially directed to this object; and although the means he is about to suggest are in themselves, in all probability, of a less magnificent character than those which the talented engineer Sir John Rennie may have suggested, yet they will perhaps be found of some service, and justify his attempt of laying them before the public, as contributory to the measure, and as applicable to others,—particularly to what appears to him important, the redemption of the large overwhelmed flat called Welsh-ground, in the mouth of the Severn, on the Monmouthshire side of the river.

Mode suggested by writer.

To elucidate the mode by which land may either be acquired from the sea, on the flow and ebb of tidal waters, or on the downward current of rivers, let us imagine that a space of eddy water within the influence of either were to be inclosed by a series of floating booms*; that this space were to be of a superficies equal to one mile each way; that these booms were so secured as to maintain their general position, but to rise and fall with the tide, or with the river floods: generally speaking, the top tidal water is not so much mixed with silt as when the strength of the tide, or its run, is in action; as the booms would thus be floating, the current with its alluvial matter, whether sand, silt, or sea-weed, would pass under them; the still water (which almost invariably exists half an hour at the full tide) would suffice to cause the heavier particles of sand to subside, and the sea-weed, mud, and half-floating matters would be stopped by the booms, which would lower themselves with the tide as it retires. When the booms are seated on the silt or sand, their weight (not being then floating) would in some measure consolidate it; and when the soil is somewhat consolidated they might serve as landing-places to enable workmen to drive piles, fix hurdle-work, or to cast chalk within the inclosure which thus they have created. By their receiving the action of the waves at the onset of the tide, and during its run, they would tend to prevent an irruption upon the rising embankment; and when the embankment is formed, they would act as protections to it. So, where there is little or no tidal water, they would serve as creating a sort of lake; and although they might be continually floating where they were situated, at the smaller end of the float, they would admit the stream with its alluvial matter, and by having an increased depth of frame at the other, partially hold back the stream, and so encourage the deposit of its earthy matter.

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* An example of the effect of floating booms may be daily seen at Blackfriars Bridge.

It was remarkable when the Timber Docks existed at Battersea, that four years' deposit of silt raised them two or three feet: they had sometimes only one mouth into the river, and that opening towards the lower end in order to receive the timber from seaward; yet the alluvial matter was clay and chalk from the uplands with little or no commixture of river or sea sand. In the docks below bridge the deposit is very similar, and many bricks have been made from the soil when dredged out of them and landed on the dry shore.

On embanking the Thames.

The river Thames is not so rapid upwards as most of the other principal rivers of England, and its tributary streams are generally of clear water; yet great is its deposit, as its mud banks, where it meets the tide, evidence, as well as the dock deposits just mentioned, and also the numerous silt and sand banks at its mouth. It is embanked almost its whole tidal length below London, and little land can be recovered except on the Essex side; but the Margate sands are in part dry at neap spring tides. Possibly nearly opposite Margate there might be an acquisition of excellent land by mooring floating booms and breakwaters to the extent of 1000 or 1200 acres; thus artificially forming an island, such as Sunk Island in the mouth of the Humber has gradually grown up to be. The benefit of such an embankment would not be confined to the posses-

Margate Sands

sion of soil, but it would be of the most important use by confining the tide into its proper channel, instead of suffering it to expand over this space: in fact, such an island as this would become a breakwater in the best of situations; one where nature has endeavoured to place it; one on which any beacons or lights might be erected; and one whereon the mariners might find refuge, instead of meeting the destruction so frequently experienced in the entrance of our so-much vaunted river.

The value of the thousand acres or twelve hundred acres thus suggested to be inclosed would, when brought into condition, be worth not less than 100,000*l.*; the cost of surrounding such a space would probably be 50,000*l.*, and the other works as much more. This, consequently, must be a national undertaking, but its importance would justify its adoption. The in-shore or Margate South Channel, and its continuation the Horse Channel, is in the charts described as a track for small vessels, and in one place near the Gore Sand there is marked 1¾ fathom only. The track for larger vessels near the Pan Sand is of but little better character; in one place it is marked at 2 fathoms only. Reducing the waterway as described would probably double the depth of these channels.

Old ships of war as break-waters.

If some of our worn-out ships of war were fitted for such a purpose by having their keels reduced, and then moored to break and deflect the tide, the experiment might be tried at little comparative expense; their being empty would give them a buoyant character; the sand which would be disturbed by any increased current they might produce would deposit itself at any existing or any artificially-created eddy, and thus this mischievous deposit would aid the object of the acquisition of land instead of being the dangerous impediment to what we have called our noblest of rivers.

Mr. Dudley Bate.

Wherever sands, dry at times, in estuaries, exhibit themselves above the water, advantage should be taken of this disposition of nature to form islands or to add to the main land: the late Rev. Mr. Dudley Bate effected this at Bradwell, *juxta mare*, on the Essex shore. That such acquisitions tend to the improvement of channels of rivers, the quotation hereto added from the Life of the late much-valued and eminent Thomas Telford will probably fully attest, and be read with pleasure; no axiom can be clearer than his, although once much disputed, viz. "that it is by the confinement of waters in regular "channels that rivers are to be improved."

The Goodwin Sands.

The Goodwin Sands are sometimes so dry at low water that parties of pleasure dine upon them: they are, unfortunately, of so perturbable a nature, that little advantage can be taken of their condition, except as to their elevation above low water: but supposing the elevated points could be consolidated and embanked so as to be always visible, and that edifices could be raised upon them, how great would be the advantage! there would then be a real breakwater in the middle of the sea. The dry space is, however, little more than a ridge, and we can hardly flatter ourselves that the acquisition of the land would be very important either as to its superficies or valuable as to its quality. Its quality must be inferior to that in the mouth of the Thames, the Lynn rivers, the Humber, or the Severn; which rivers bring down the rich alluvial soil of the countries whence they originate. Mud is found at the south-east quarter of the Margate Sand in six-fathom water, chalk in seven fathoms.

Chalk, pebbles, or shingle might promiscuously be thrown within any sets of frames which might be employed in works of embanking; they would combine with each other, imbed themselves in the sand or silt, and with the protection of a few months by floating breakwaters, become consolidated, and possibly concreted. If the power of the sea is unable to remove that part of the Goodwin Sands which is called the Barrier, and which has on its outer margin from nine to eleven, and even twelve fathom water, it may fairly be inferred, that similar soil would resist the billows of the North Sea, impelled by a north-east wind; for both the Margate and Goodwin Sands lie in a similar direction, as regarding this part of the ocean,—both much exposed to the violent winds of the north and north-east.

Bars at the mouths of rivers.

The bars at the mouths of rivers are the continual subjects of complaint; their causes are the deposit made at the time of eddy at full tide, or by the reduction of current by the expanse offered by the retirement of the land: every bar which rises near the surface of the ocean should if possible be reduced and rendered fixed land and so should become a breakwater; the channels at the ends of the bar, or wherever its nature indicates proper places to encourage a greater depth of water, should be assisted by having floating constructions, which, lowering with the tide or stream, would increase the rapidity of the current in the direction which nature should seem to prefer: observation would easily lead to a proper judgement on this head. The disposition of any estuary to silt should be directed to the creation of deposit at the most convenient places, and every effort should be made to prevent moveable sands. The operation of nature in bringing seaward alluvial matters, and in producing, by the attrition of pebbles and the impinging of the waves on rocks, shores and headland, is continual: the works of art must therefore be in constant operation to be perfectly successful; and as, from storms and accidental circumstances, changes are constantly taking place, these changes must be watched, and the cares of mankind applied to take advantage of these occurrences; and the located inhabitants may thus benefit themselves, and hold out an example to posterity.

When the shoal or bar is nearly or altogether generally distributed at the mouth of a river, it will be desirable to place floating caissons on both banks, and also solid piers, because every means of reducing the space between the shores will tend to increase the rapidity of the emerging current, as by the direction of the stream into the mid channel there will be less danger of getting ashore on the banks: this observation is, however, subject to the especial circumstances which will present themselves as to the prevailing winds or tides acting upon the estuary.

Extract from the Life of the late THOMAS TELFORD, *Civil Engineer.—See Quarterly Review, June* 1839.

"If you cut a canal, you are sure that the removal of earth and the usual apparatus of locks will attain your object; but the improvement of harbours, and of drainage by weirs, depends on management and direction of natural causes and effects, in which I may say, observation has been so torpid, that till twenty years since, much more harm than good has been the result of interference. All the reports of Mr. Smeaton, and some made scarcely sixteen years since, prove that in large drainages near the sea, natural outlets or weirs were always recommended to be stopped by dams and sluices to prevent the tide from entering, which obstacles equally prevented the drainage-water from free passage outward.

" Three inches fall (downward slope) in a mile makes water move slowly; at four inches declivity in a mile, water acquires a moderate velocity sufficient for any drainage operation; so that the sill (threshold) of a sluice, if laid one foot too high, will almost prevent the natural drainage of twelve miles above, by limiting the current to three inches to a mile. On the same principle, if a drainage outlet, obstructed by what may be almost deemed the caprice of winds and tides and of accumulated sand-banks, in consequence shall double its length and creep through a dubious crooked channel, it is evident that a three- or four-inch fall may become an inch, which is ineffectual.

" The sound principle which results from these facts is to give free ingress to the tidal water, guarding against inundation by raising the banks of your river, and also straightening its course, so as to lose no downfall; this increased downfall and increased tidal water is made to bear directly upon the old sand-banks; and if the connexion with deep water can be established in this manner, you obtain a harbour of easy access, and the old-fashioned precarious drainage of land by windmills becomes unnecessary, the dams which previously hindered daily drainage at low water being for ever removed.

" All this was to be seen in progress below Wisbeach and Long-Sutton Bridge, and the impetuous fall of the water in the recess of a spring-tide had found its way through the sands in the beginning of August 1830. With a view to this event, the old channel of the river Nene had been boldly dammed across in the middle of July, and the current turned into the straight cut prepared for it. All this constitutes the 'Nene Outfall.' When I saw it meet the sea, four miles below the Washway, (now the drawbridge at Long-Sutton,) at three-quarters ebb, the torrent rushed down four feet in the last quarter of a mile; this of course carries off the sand daily; and by the law of nature, the four-feet fall will recede inland until nearly a uniform inclination or slope shall penetrate to Wisbeach, which will become a sea-port of importance, and above it 180,000 or 200,000 acres of fen land will retain nothing of its hitherto nature except unparalleled fertility."

THE END.

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